Fairer Usage Contracts For DRM*

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ABSTRACT

DRM has been widely promoted as a means to enforce copyright. In many previous papers, it has been argued that DRM gives too much power to rights holders and actually goes beyond the restrictions provided by copyright laws. In this paper we argue that DRM does not actually implement the fundamentals of copyright law, and is rather a mechanism for enforcing licence and contract restrictions on digital data. However, we believe that DRM does have a place in the digital distribution of copyrighted works and present two mechanisms that would allow users to get a more balanced deal from the rights holders. The mechanisms we present also allow for newer business models that cannot be easily implemented with current DRM systems.

Categories and Subject Descriptors

K.4.1 [**Computers and Society**]: Public Policy Issues—*Intellectual property rights*; K.5.1 [**Legal Aspects of Computing**]: Hardware/Software Protection—*Copyrights, Licensing*

General Terms

Design, Languages, Legal Aspects, Security

Keywords

Fair use, DRM, copyright, negotiation, credential, rights expression languages, REL, ODRL, persistent access control

1. INTRODUCTION

Copyright allows the rights holders to retain a degree of control on how the work is reproduced, distributed and depending on the medium of the work, the terms under which it is allowed to be broadcast or performed to a mass audience. The original aims of copyright law was to encourage the writing of books, although it later evolved to protect the commercial interests of the rights holders [16]. By having a copyright on a work, rights holders are compensated for users making use of their work; and perhaps in this way others could be motivated to create and market copyrighted work.

Enforcement of copyright law has always been *passive* in the physical world. There are usually no mechanisms to protect a work from being reproduced, distributed, broadcast or performed without agreement from the rights holders. If the rights holders become aware of an infringement in copyright, they can take legal action against the responsible parties. In the physical world, mass scale copyright infringement is expensive, usually time consuming, relatively easy to track and reproduction quality cannot be guaranteed to be the same as the original.

However, in the digital world, digital media can be reproduced exactly, and the Internet usually provides cheap, reliable and very fast distribution channels. While technologies such as various watermarking algorithms can allow for the identification of reproduced copies, tracking the source of the reproduction and distribution becomes very difficult. With the advent of load sharing peer-to-peer networks like bittorrent, it is now virtually impossible to stop distribution of digital data on the Internet or to isolate all the sources of reproduction [5].

Digital Rights Management (DRM) software has been promoted as the solution to protecting copyright of digital media. However, while DRM theoretically allows for the active protection of copyright, it also allows for the possibility of the rights holders to assert control that they do not necessarily have [22, 10]. DRM systems can theoretically control and track where, when and how a work is used; together with who uses the work. Thus, most of the criticisms on DRM systems have revolved on the potential (and in some cases actual) invasion of user privacy [10, 19] and the amount of control rights holders can assert [3, 4, 9].

While DRM systems can limit the usage of a work; current systems do not allow for exceptions to those limits. In most countries, copyright law allows for a number of instances that allow users to make use of a work that would otherwise be a violation of copyright. These exceptions are known as *fair dealing* in South Africa, *copyright exceptions* in Europe and *fair use* in the USA. However, as has been widely discussed in both academia [13, 12, 22] and in the press

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and public forums [3, 4, 14], fair use is almost impossible to implement on a computer. Fair use is necessarily vague, and Felten described fair use as a "*feature for lawyers*" – applications should be argued in court on an individual basis [13]. Felten further argued that evaluating fair use would require sophisticated AI, and the factors involved are "*AI-hard problems*" [13]. Mulligan et al. had previously argued that Rights Expression Languages (RELs) could not express or even approximate most of the limitations posed in copyright law, and thus DRM systems in fact "*distort copyright law*" [18].

But, as Dusollier discusses in [11], the European Copyright Directive (ECD) requires that technological measures that protect copyright must allow the users to enact the exceptions allowed by the ECD [11, 2]. While Dusollier agrees that the directive does protect users, but argues that rights holders are also given a loop hole that allows them to side step the fair use requirement all together. This loophole removes the requirement of having fair use provisions if the work is "*made available to the public on agreed contractual terms in such a way that members of the public may access them from a place and at a time individually chosen by them*" [2].

Yet another argument on fair use revolves around the appropriateness of current fair uses in the digital environment. In [16] and in [14], Masango and Harper respectively argue that current fair uses are unsuitable for the digital environment. Masango argues that, in the past, invention of new technologies led to the evolution of both copyright law and copyright exceptions. However, there have been no such updates for digital works. Both argue, that if fair use is to be successfully implemented in a digital environment, a new definition of fair use in a digital environment is needed.

As discussed earlier, in [18], Mulligan et al. concluded that DRM systems distort copyright law. This paper is divided into two major sections. In section 2, we argue that DRM systems do not actually implement some of the fundamental aspects of copyright law in the first place and thus should not be considered as technology enforcing copyright law. Rather, DRM is only a mechanism that can be used to enforce contracts between two parties over the use of particular digital data. We also argue that this is not necessarily a bad thing as long as the contracts themselves are fair to both parties. In sections 4 and 5, we detail two mechanisms which allow rights holders more flexibility in expressing use licenses and allow consumers a fairer contracts. We believe both approaches allow the possibility of greater freedoms for the consumers without compromising the needs of the rights holders.

2. DRM AND COPYRIGHT

The core protections that copyright provides is limitations on the reproduction and distribution of copyrighted works. Subsequently, DRM systems have also tried to enforce such limitations. The DRM controllers that are involved in enforcing the rules of the use license can be implemented at various levels in a device as shown in figure 1. However, if the user wants to make a reproduction or distribute the copyrighted work, the DRM controller at any level can usually be easily bypassed without tampering with the DRM controller itself.

Application level DRM controllers (like Apple's iTunes) have no control on the operating system; and thus reproductions (copy and paste is a basic function of Mac OS X and Windows) or distribution (through email etc) is achieved quite easily. Microsoft's RMS is the only DRM controller at the moment that has some operating system hooks but it does not actually prevent reproductions and distribution, and any operating system level controller can easily be bypassed through the use of a non-DRM enabled operating system (through the use of a Linux live-cd for example). While DVD-CSS can be considered a media specific DRM system, future DRM systems are likely to be on a chip [21]. But if the DRM protected data is stored on a removable media or stored on a hard disk, using a non-DRM enabled device will allow the user to copy and distribute at will. Thus, as long as the majority of computer components (and other electronic devices) support multiple operating systems and removable components, DRM will never be able to allow for limitations on copying and distribution.

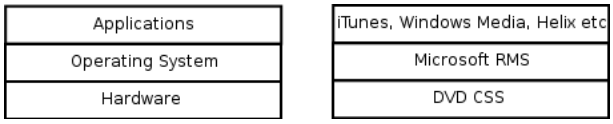

Figure 1: Different levels of implementing DRM Controllers

Most of the current DRM systems rely on restrictions of usage to enforce copyright. For example, most music stores restrict users to playing music they have bought to a small number of different PCs and devices. No current DRM system offers full portability where users can migrate to any machine and still access the protected works they have bought access for. Similarly, many other legitimate cases where reproduction is allowed under fair use, like backing up, is prohibited if not severely limited.

Copyright laws, like the South African Copyright Act, place very few restrictions on how a copyrighted work is used [1]. In most cases, the act provides restrictions for public broadcast, public performance and adaptations. Similarly, Chapter 2 of the ECD, Rights and Exceptions, is divided up into four sections – reproduction rights; rights of communication to the public of works and rights of making available to the public other subject-matter; distribution rights; and exceptions and limitations [2]. There are also no specific restrictions on how a user makes use of a copyrighted work. This is the same scenario in US copyright law, and for this reason Samuelson observes that DRM systems go beyond copyright law [22].

Thus we believe that DRM is not about enforcing copyright, but rather on the restrictions on how protected works are used and is not dissimilar to usage licenses. This would mean that the provisions in Article 6(4) of the ECD, regarding the provision of fair use, would not apply to DRM systems – all current DRM systems allow the user to choose at least one device (usually a computer) that would be used to render the DRM enabled work, and time restrictions, if any, are rather broadly defined (subscription based music stores for example give users a month to listen to the music).

2.1 "Personal Use"

In [19], Mulligan et al. described a set of rights that

the user expects to have. These rights do not necessarily have any legal backing, but are practiced none the less by the majority of users. The authors categorised the rights they discussed into three categories: portability, excerpting and limited relationship and interaction with the copyright holder. The authors did not explore other uses that could fall under "personal use" nor did they discuss how users felt about DRM systems that limit these uses. Thus further research is necessary in regards to the full spectrum of rights that the users expect from DRM enabled work.

2.2 Privatisation of Copyright – Buying vs. Licensing

When a person buys a CD or a book, the person buys the right (with certain limitations) to make non-commercial use of the copy as they see fit. Licensing is however a contractual process; and contracts (with certain key restrictions) [1] can specify any terms and conditions agreed to by both parties. While DRM protected media is often sold as the user "buying" the digital work, the actual process is more like licensing.

If DRM becomes purely a mechanism for controlling access and usage to protected works (and drops the pretence that it is all about the protection of copyright); it does not imply that the consumer will be in a worse position.

In [14], Harper argues that full contractual DRM systems can spawn different business models. This argument is partly supported by the current music download business[2]. The leading music store, Apple's iTunes, has a less restrictive rights policy when compared to its peers. Currently, music stores making use of DRM make use of two different business models – the rental model in the subscription music stores and the pay per song or album model. But these business models can be further extended. For example, would there be consumers willing to pay lower than current per song downloads if the rights they have are further restricted? Conversely, would consumers be willing to pay more for music that has very few (if any) restrictions?

Licensing of copyrighted works is already used to regulate the commercial use of copyrighted work. In South Africa, a *copyright tribunal* is available to anyone who has disputes regarding the terms and conditions in a licensing agreement where the applicant feels that the licensing body proposes unreasonable terms for licenses or that the licensing body refuses to grant a license without reasonable grounds [1]. Similarly, the copyright tribunal[3] can play a very important role in the future of DRM protected works as it can provide consumers with a legal recourse for license disputes. For example, if traditional fair uses are not allowed by the license terms, and are not part of any available licenses from the rights holders, the user should be able to bring the dispute to the copyright tribunal.

Current DRM systems offer only shrink-wrap or click through licenses, and do not allow the users any input on the terms of the use licenses. Thus users could make use of copyright tribunals to protest current terms in use licenses especially if the work is available only in the digital form. In the remainder of this paper, we present two different mechanisms to allow for more flexible rights assignment to users. In our first mechanism, we present REL extensions that allow for the expression of contract negotiations as well as a simple protocol that would allow users to negotiate contracts. In our second mechanism, we present a role based approach to DRM use licenses (e.g. a journalist can excerpt from this media). Both mechanisms can be used to allow for fair use should DRM be fully implemented as protection of copyright.

[1]These restrictions usually prohibit a contract from requiring illegal actions from one of the parties – for example, a contract cannot usually use prohibited substances such as cocaine as a means of payment.

[2]We assume that other factors such as usability of the system and the types of portable music players supported also play a key role in how successful an online music download business is.

[3]We are still investigating if other countries have legal structures similar to Soth Africa's copyright tribunal.

3. RIGHTS HOLDERS: REPRODUCTION AND DISTRIBUTION

In [20], Park et al. discussed the various categories of content protection systems. One of their categories involved the separation of the protected data and the control set (or use license). Assuming strong encryption is used, and the keys contained in a use license themselves are adequately protected, it would not matter how the protected data file is replicated and distributed. When a user wants to access the data, they would require a license. This mechanism is not less secure than an embedded license, as the basis of the security provided by DRM still depends on how well the keys are protected. Microsoft's Windows Media 9 promotes this approach to DRM [17].

In the first approach we present, a separation of the data and use license is necessary to achieve the full benefits. The separation of data from the use license allows the possibility to exploit peer to peer systems for distributing data. Peer to peer systems are arguably more efficient and effective in data distribution that the centralised server approach. For example, many Linux vendors have found bit-torrent to be more efficient in distribution of CD images than the centralised approach. However, both approaches we present can be utilised with an embedded use license in the DRM work.

4. FIRST APPROACH – NEGOTIATING A USE LICENSE

Use licenses in DRM systems are essentially contracts between the rights holders and the users. However, while most contracts have inputs from the both parties; use licenses have only the rights holders' inputs. In fact, current DRM systems do not have mechanisms to allow the end user to have input on the terms and conditions of the use license. In [18], Mulligan et al. commented on the fact that there are no RELs that allow users to express their needs, and the protocols for creating use licenses for end users do not take any inputs from the end user. Thus to allow users to communicate with the rights holders, there is a need for both a protocol and a language to express the communication.

We propose that the end user be allowed to negotiate the use license with the rights holder. In [15], Jamkhedkar et al. also proposed a negotiations mechanism to allow for flexible security levels for DRM packages. As far as we are aware, our paper is the first description of the syntax and the protocol for conducting negotiations in DRM systems.

There are two parties in a negotiations system – a license server which acts as a proxy for the rights holders and the end user. Negotiations make use of a simple *request-response* model, and can be broken up into four simple steps, as shown in figure 2.

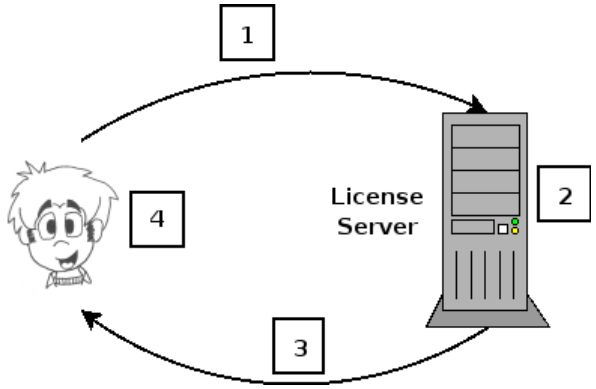

Figure 2: Simple Negotiations Protocol

Step 1: The end user requests the license server for a set of rights (or changes to an existing set of rights).

Step 2: The license server evaluates the request against a set of licenses or rules that have been set-up previously by the rights holders. Some of these rules might require a role based authentication – for example, rights holders may allow only accredited journalists the right to excerpt from a protected work.

Step 3: The license server presents the user with one or more sets of rights that match closely to the requested rights.

Step 4: The user can request refinements to the offered rights packages until he or she is satisfied (and start from step 1) or can choose one of the rights packages on offer.

This process immediately offers a new business model; allowing different sets of rights at different prices. For example, a basic rights package for a movie on demand service could allow the user to play the movie on three different devices expiring in three days from the rental date. The user could then be allowed to purchase additional rights to increase the number of devices or extend the expiry date. With a separate use license, this model can be further extended to allow end users to "renew" the rental after the initial purchase has been completed. It also allows for added flexibility – a journalist could have rented the movie for personal reasons, but could then decide to include it in his next movie reviews segment. The journalist could then request excerpt rights using a journalist credential. These use models are not possible in current DRM systems, and our mechanism allows DRM to enhance and facilitate "licensed usage" through accommodating greater degrees of flexibility.

The negotiations model requires a REL capable of bi-directional communications, a REL capable of expressing rights offers from rights holders, a protocol for conducting negotiations, an algorithm that can match requests from end users to what the rights holders are willing to give and a credentials system that will allow the end user to prove certain characteristics to the rights holders. The outline of the negotiations protocol is outlined above, and quite a few pattern matching algorithms could be employed to match requests from end users to rights holders offers. An established REL, ODRL, has an "offer" syntax which allows rights holders to express rights offers to the end user.

4.1 Bi-Directional REL

As discussed earlier, there are currently no mechanisms to express the needs of the user to the rights holders. We believe that the use of a REL that supports bi-directional communication is better than a separate language because there will be no need to translate the requests from the user to the REL used by the rights holders.

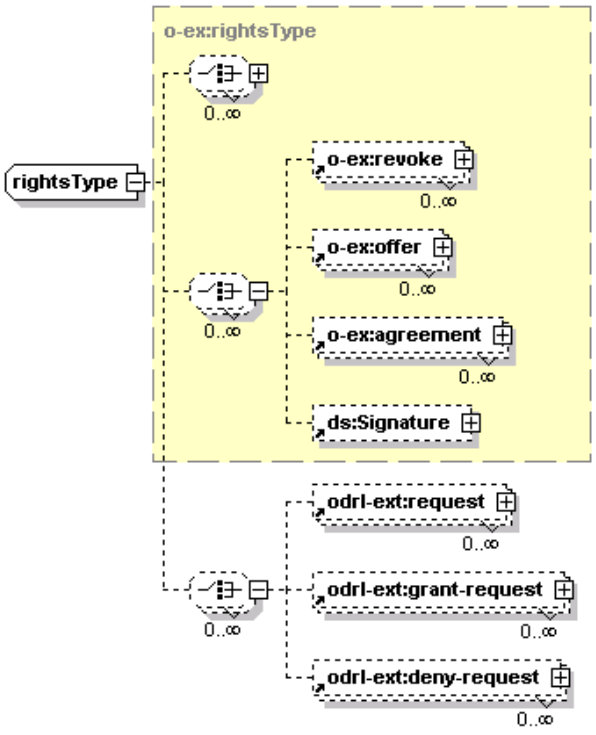

Figure 3: XML schema of the extended ODRL *rightsType* type

In [8], Arnab et al. discussed bi-direction extensions to the ODRL REL and how they can be used for negotiating fair use. In an earlier technical report [6], similar extensions to XrML were discussed. The user *requests* changes to an existing license, or the terms he/she would like for a new license to the rights holders. The rights holders can then evaluate the requests and grant the request, deny the request or provide terms that are similar, but not exact, to the request. The user can then further refine the license terms and carry on negotiating with the rights holders. Once the user is satisfied with the terms and conditions he/she can complete the transaction to purchase the use license. The user can of course leave negotiations if none of the offers from the rights holders are satisfactory.

The extensions discussed by Arnab et al. allow for the

user to request additional rights, remove existing rights or replace a set of rights with a different set (and not necessarily of the same class) of rights. If the rights holders grant the request, they can choose to either create a new license (invalidating a previous license) or create a license addendum with the changes. While the first approach is easier to maintain and handle, the second approach does allow for short temporary license changes. For example, if a journalist wants to get excerpts for the purpose of a review of a work he/she previously bought for personal use, the rights holders can grant a temporary license addendum that allows excerption for a limited time. After the expiry of the addendum, the original license terms come back in effect. However, the use of addenda could prove to be too complex to track and manage.

4.2 Credentials

Rights holders may wish to offer certain rights only to specific roles (or vary the charge of rights according the roles of the users). For example, as in an earlier example, rights holders may choose to offer excerpt rights only to journalists for free. Alternatively, a distributor may choose to offer discounted rights to members of a professional organisation (for example, the ACM may wish to offer certain articles at a discount to IEEE members). Thus there needs to be a mechanism for the end user to prove that they have a certain role (like a journalist, an academic, a member of a professional organisation etc.). We propose the use of credential servers to serve in this capacity.

The credentials servers can work like ticket granting servers in Kerberos [23]. The user can authenticate themselves to the credentials server, which can generate a credentials ticket. This ticket can then be given to the license server. Alternatively, the license server can request a credentials ticket on behalf of the user from the credentials server. The first approach has the advantage of limited re-use of the credentials ticket while the second approach is more user friendly.

For a credentials based system to work, there is a need for a large set of trusted credentials servers. Ideally professional organisations like the ACM or IEEE, or trusted institutions should host the credentials servers.

5. SECOND APPROACH – CREDENTIALS BASED RIGHTS

Most RELs already have syntax that allow for rights that can be exercised under certain circumstances. ODRL for example has a *constraint* construct, which can be used to limit the parameters of a certain right – for example, a print right can have a constraint, number, with a value of 5 to restrict the end user to only print the media a maximum of 5 times. The *condition* construct in XrML provides similar functionality.

In our second approach, we propose the addition of a *credential* constraint for ODRL. The parameters of the constraint would then be credential ticket type that the user needs to produce to exercise the right. We acknowledge that this approach would require a very strong identity management system to work and is a deterrent for adoption of this mechanism. Figure 4 gives an example that allows a user with a *journalist* credential to excerpt.

However, a single credential constraint is not enough but

```
<permission>
   ...
   <excerpt>
      <constraint>
         <credential>
            <CredentialsType>journalist</type>
         </credential>
      </constraint>
   </excerpt>
   ...
</permission>
```

Figure 4: Simple usage of a credential constraint

neither is a list of credentials. Rights holders may wish to require different sets of credentials for for a particular right. For example, rights holders may require either a user to present both an academic and a researcher credential or a journalist and a Reuters credential to access a certain right. A list of credentials will not be able to express this. For this reason, we use an "and list" and an "or list" to represent a set of rights. Figure 5 shows the XML schema for our credential constraint.

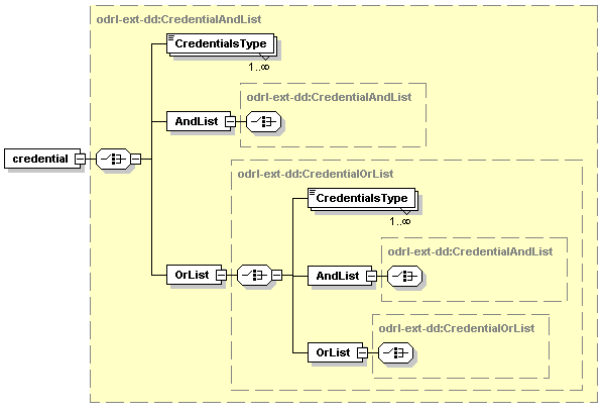

Figure 5: XML schema for a credential constraint for ODRL

A credential system can also be extended to provide semi-location based authentication through secondary (and maybe untrusted) credentials. A secondary credential could be issued to prove that the user is using a specific machine or is present at a specific location. It would be very difficult to allow trusted credentials servers for these functions, but even if they are untrusted, they can be used to provide some limits for the end user. Using the journalist example again, the rights holders may decide only to offer an excerpt right for journalists if the journalist makes use of a machine logged onto the news organisation's network during excerption. The primary credential would prove that the user is an accredited journalist, while a secondary credential could be used to prove that the journalist is logged onto the network before being allowed to excerpt. This approach could be very useful for enterprise DRM systems, where the aim is to control the use of sensitive corporate data.

Alternatively, secondary credentials could be used to in-

dicate what type of work the user is engaged in. Thus the academic can request a local credential server to provide a "research" credential before making an excerption. While this scenario could be implemented in the workplace (as it allows employers to monitor the productivity of the users indirectly), it is infeasible for use in a private home; as any such online system has great potential to infringe the user's privacy.

6. CONCLUSION

We have argued that DRM systems regulate how users make use of protected works rather than being mechanisms to enforce copyright law. For this reason there is a need to create usage contracts that are more flexible and "fair" to the end user. We have presented two approaches that could be used to provide more flexible use licenses as well as some new business models that could exploit the flexibility.

Using credentials and negotiations allow for greater flexibility and newer business models for the rights holders. It also allows the rights holders to retain a greater control on their copyrighted material. The credentials extensions to ODRL discussed in section 5 would also help in creating templates use license offers. However, negotiations require the extension of the core syntax of most RELs, and a substantial set-up time to create necessary templates.

Using credentials only through the use of a "credentials" constraint in ODRL is a simpler approach, requiring minimal extensions to the current standard data dictionary for ODRL. However, while the constraint allows potentially for greater freedoms for the consumer, the rights holders lose some of the control that is offered by the negotiations approach, especially as the rights holders could lose control of which credentials servers they trust.

We believe that the second approach could be useful for the mass market of certain DRM enabled products like music, if the right balance of rights are achieved. The negotiations approach has a wider application, and ultimately offers more for both the rights holders and consumers alike.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

[1] Copyright act 98 of 1978. 2000 ed., vol. 2 of *Statutes of South Africa*. Juta, 2001, pp. 2–214–2–234. As ammended by (acts/year): 56/1980, 66/1983, 52/1984, 39/1986, 13/1988, 61/1989, 125/1992, 38/1997, 9/2002.

[2] Directive 2001/29/EC Of the European Parliament and Of the Council of 22 May 2001 on the harmonisation of certain aspects of copyright and related rights in the information society. Online, 2001. Also known as the "European Copyright Directive".

[3] DRM From the Viewpoint of the Electronic Industry. *Slashdot* (2003).
URL:
http://slashdot.org/article.pl?sid=03/11/25/1821218.

[4] Linux and DRM? *Slashdot* (2004).
URL: http://ask.slashdot.org/article.pl?sid=04/02/10/2329229&mode=thread.

[5] Give and yea shall receive – The Bittorrent Revolution. *SA Computer Magazine 12*, 10 (February 2005), 38 – 43.

[6] Arnab, A., and Hutchison, A. Extending ODRL and XrML to enable Bi-directional communication. Departmental Technical Report, No. CS04-28-00, University of Cape Town, 2004.

[7] Arnab, A., and Hutchison, A. Security Considerations for an Idealised DRM Framework. In *Proceedings of the South African Telecomunication Networks and Applications (SATNAC) Conference 2004* (2004).

[8] Arnab, A., and Hutchison, A. Extending ODRL to Enable Bi-Directional Communication. In *Proceedings of the 2nd International ODRL Workshop, Lisbon, Portugal* (2005).

[9] Bechtold, S. Reconciling DRM Technology with Copyright Limitations. IVir, Buma/Stemra - Copyright and the Music Industry: Digital Dilemmas.

[10] Cohen, J. DRM and Privacy. *Communications of the ACM 46*, 4 (2003), 47–49.

[11] Dusollier, S. Fair Use By Design in the European Copyright Directive of 2001. *Communications of the ACM 46*, 4 (2003), 51–55.

[12] Erickson, J. Fair Use, DRM and Trusted Computing. *Communications of the ACM 46*, 4 (2003), 34–39.

[13] Felten, E. Skeptical view of DRM and Fair Use. *Communications of the ACM 46*, 4 (2003), 57–59.

[14] Harper, G. Will we need fair use in the twenty-first century? *Copyright Crash Course, University of Texas* (2004).
URL: http://www.utsystem.edu/OGC/IntellectualProperty/fair_use.htm.

[15] Jamkhedkar, P. A., and Heileman, G. L. DRM as a Layered System. In *Proceedings of the Fourth ACM Workshop on Digital Rights Management* (2004), A. Kiayias and M. Yung, Eds., ACM, pp. 11 – 21.

[16] Masango, C. Digital license agreements and its effects on academic library users. In *LIASA Acquisitions Interest Group (LACIG) - Third Southern African Library Acquisitions Conference* (2004).

[17] Microsoft. Microsoft windows media data session toolkit, 2003.

[18] Mulligan, D., and Burstein, A. Implementing Copyright Limitations in Right Expression Languages. In *Proceedings of the 2002 ACM workshop on Digital Rights Management* (2002), ACM.

[19] Mulligan, D., Han, J., and Burstein, A. How DRM Based Content Delivery Systems Disrupt Expectations of "Personal Use". In *Proceedings of the 2003 ACM workshop on Digital Rights Management* (2003), ACM, pp. 77–89.
URL: http://doi.acm.org/10.1145/947380.947391.

[20] Park, J., Sandhu, R., and Schifalacqua, J. Security architectures for controlled digital information dissemination. In *Proceedings of the 16th Annual Computer Security Applications Conference* (2000).

[21] Rosenblatt, B. DRM for the Enterprise, 2004.
[22] Samuelson, P. DRM {AND, OR, VS.} The Law. *Communications of the ACM 46*, 4 (2003), 41–45.
[23] Stallings, W. *Network Security Essentials – Applications and Standards*, international second ed. Prentice Hall, 2003.

APPENDIX

A. XML SCHEMA OF THE CREDENTIAL CONSTRAINT

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema targetNamespace="http://people.cs.uct.ac.za/~aarnab-ODRL-DD"
    elementFormDefault="qualified" attributeFormDefault="qualified"
    version="0.1" xmlns:odrl-ext-dd="http://people.cs.uct.ac.za/~aarnab-ODRL-DD"
    xmlns:xs="http://www.w3.org/2001/XMLSchema"
    xmlns:o-ex="http://odrl.net/1.1/ODRL-EX">

    <xs:import namespace="http://odrl.net/1.1/ODRL-EX"
        schemaLocation="http://www.odrl.net/1.1/ODRL-EX-11.xsd"/>

    <xs:annotation>
        <xs:documentation>
            XML Schema extends ODRL Expression Language Datda Definition Schema
            by specifying an elemnt to allow credentials as constraints.

            Alapan Arnab
            Validated with XMLSpy 2004
        </xs:documentation>
    </xs:annotation>

    <xs:element name="credential" type="odrl-ext-dd:CredentialAndList"
        substitutionGroup="o-ex:constraintElement"/>

    <xs:complexType name="CredentialAndList">
        <xs:choice>
            <xs:element name="CredentialsType" type="xs:string" maxOccurs="unbounded"/>
            <xs:element name="AndList" type="odrl-ext-dd:CredentialAndList"/>
            <xs:element name="OrList" type="odrl-ext-dd:CredentialOrList"/>
        </xs:choice>
     </xs:complexType>

     <xs:complexType name="CredentialOrList">
        <xs:choice>
            <xs:element name="CredentialsType" type="xs:string" maxOccurs="unbounded"/>
            <xs:element name="AndList" type="odrl-ext-dd:CredentialAndList"/>
            <xs:element name="OrList" type="odrl-ext-dd:CredentialOrList"/>
        </xs:choice>
    </xs:complexType>
</xs:schema>
```

Figure 6: XML Schema of the Credential constraint in ODRL